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Measuring the TCO of Tape Storage Solutions

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Introduction

This tutorial presents a framework and financial methodology for deciding whether an enterprise should replace its current “status quo” tape storage solution with a new “proposed” solution, and the economics related to that decision. The framework and methodology are explained by following an illustrative business case from beginning to end. Each of the value drivers that contribute to the cost of the status quo and proposed tape storage solutions are analyzed in this illustrative business case. Aggregate analysis of the value drivers is then used to calculate the discounted total cost of ownership (TCO) savings, which is the difference in TCO between the status quo and proposed solutions. Finally, additional financial measures further evaluate whether it is in the enterprise’s financial interest to replace the status quo solution with a proposed tape storage solution.

Illustrative Business Case Assumptions

The illustrative business case assumes that Goodstuff Company (a fictitious company) currently operates three diverse tape libraries, which contain a total of 40 tape drives. The enterprise currently has 11,000 cartridges stored in slots within the three libraries. An off-site disaster recovery site holds 5,000 more cartridges. Goodstuff has purchased the libraries and drives.

The proposed solution will totally replace the current libraries and drives with improved models, which will also be purchased rather than leased. The tape drives that Goodstuff is purchasing have significant advantages in throughput, allowing Goodstuff to accomplish the same workload with only 25 tape drives as compared to the 40 currently installed. As an additional advantage, the new tape drives have double the data capacity of the older drives. This will allow Goodstuff to utilize significantly fewer cartridges than in the current tape storage solution, while also decreasing their need for additional cartridges to accommodate data growth.

Upon careful review of Goodstuff's cartridge growth patterns after the conversion to the new drive types, it was determined that Goodstuff can dramatically reduce their overall slot requirements. This will allow Goodstuff to utilize only one library, rather than three. The new single library that Goodstuff will be deploying is much more space and power efficient than the existing environment.

Goodstuff believes that, overall, the new architecture will enhance storage administrator productivity because of its superior reliability, ease of capacity additions, and ability to service on the fly. Additionally, the current staffing model has three full-time operators, one assigned to each library. After the transition, Goodstuff believes that they will need only one operator, for the single proposed library.

The cost of ownership of the proposed and status quo tape storage solutions is measured over a period of three years, known as the *financial planning horizon*. An enterprise's financial planning horizon can be as short as one year or can extend to as many as seven or more years.

Value Drivers

Value drivers allow for the analysis of status quo and proposed cost of ownership in terms of modular elements. Each value driver can result in positive value (proposed cost less than status quo) or negative value (proposed cost greater than status quo).

Value drivers fall into four major categories: infrastructure costs, storage management staffing, application performance, and business risk mitigation.

- **Infrastructure costs** include easily measurable cash outlays, such as those for storage hardware, hardware maintenance, and software. They also include some less easily measurable costs for datacenter space and power, and miscellaneous implementation costs.
- **Storage management staffing** compares the staff effort needed to manage the current and proposed storage solutions.

- **Application performance** compares the costs of underperformance in terms of availability, reliability, and response time.
- **Business risk mitigation** compares the potential costs associated with threatening incidences, such as the need for data recovery following a disaster.

The complete structure of tape storage value drivers is as follows:

- **Infrastructure costs**
  - Hardware
  - Media
  - Offline cartridge storage
  - Hardware maintenance
  - Software acquisition and maintenance
  - Environmental
  - Wide-area network
  - Other implementation costs
- **Storage management staffing**
  - Storage architect productivity
  - Storage administrator productivity
  - Operator productivity
- **Application performance**
  - Unscheduled downtime
  - Scheduled downtime
  - Data recovery speed
  - Backup window duration
  - Batch tape processing time
  - Transaction response time
- **Business risk mitigation**
  - Backup reliability
  - Disaster recovery

An example of each value driver is presented below in the context of the illustrative business case. To avoid a false sense of precision, all dollar amounts are rounded to the nearest $1,000.

Hardware

This value driver measures the costs of acquiring the storage hardware, along with the financial repercussions of disposing of the current hardware. The cost structure depends on whether the status quo and proposed hardware are leased or purchased.

In the illustrative business case, both the status quo and proposed libraries and drives are purchased. The proposed investment is the hardware purchase price, offset by the resale value of the current hardware. Storage hardware usually loses a material part of its resale value immediately upon delivery, with further declining value due to technological obsolescence, depending on the age of the equipment. In case the current hardware is reused elsewhere within the enterprise, the resale value would reflect the value of this alternative use.

TABLE 1. PROPOSED HARDWARE PURCHASE COSTS

HARDWARE (PURCHASE) ASSUMPTIONS			STATUS QUO	PROPOSED
A. Purchase price (after discount) for one new library				$450,000
B. Purchase price (after discount) for 25 new drives				$500,000
C. Resale value of three current libraries				$100,000
D. Resale value of 40 current drives				$150,000
CASH FLOW	**INVESTMENT**	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost		$0	$0	$0
Proposed cost	$700,000	$0	$0	$0
Excess cost of status quo	-$700,000	$0	$0	$0
PROPOSED INVESTMENT = A + B–C–D				

As a variant to this illustrative business case, consider one in which both the status quo and proposed libraries and drives are leased rather than purchased. Here, the proposed investment would be the lease termination fees of the current hardware. Lease termination fees may approximate the total (with a small discount factor) of the remaining lease payments.

Both the status quo and proposed annual costs reflect hardware lease payments. This business case would benefit by the fact that fewer libraries and drives are leased in the proposed solution.

TABLE 2. STATUS QUO AND PROPOSED HARDWARE LEASE COSTS

HARDWARE (LEASE) ASSUMPTIONS			STATUS QUO	PROPOSED
A. Annual lease cost for three current libraries			$180,000	
B. Annual lease cost for 40 current drives			$200,000	
C. Annual lease price (after discount) for one new library				$140,000
D. Annual lease price (after discount) for 25 new drives				$180,000
E. Lease termination fees for three current libraries				$90,000
F. Lease termination fees for 40 current drives				$80,000
CASH FLOW	**INVESTMENT**	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost		$380,000	$380,000	$380,000

Proposed cost	$170,000	$320,000	$320,000	$320,000
Excess cost of status quo	-$170,000	$60,000	$60,000	$60,000
STATUS QUO YEAR 1–3 = A + B				
PROPOSED INVESTMENT = E + F				
PROPOSED YEAR 1–3 = C + D				

Media

The annual purchase cost of new cartridges, as data grows and worn cartridges are recycled, represents a major cost item of tape storage solutions. This cost is influenced by four major factors: the unit cost of cartridges (declining over time), the data capacity per cartridge, the cartridge percent utilization, and data growth. Generally, the proposed new solution will have a higher cost per cartridge, which is more than offset by improved cartridge capacity and utilization leading to fewer purchased cartridges. Utilization can be strongly influenced by a virtual tape solution component, which is not reflected in this illustrative business case.

After this initial conversion investment, the proposed solution shows significantly fewer media costs, because more data is stored on each cartridge, and fewer new cartridges need to be purchased to accommodate data growth.

TABLE 3. STATUS QUO AND PROPOSED MEDIA LEASE ASSUMPTIONS AND COSTS

HARDWARE (LEASE) ASSUMPTIONS		**STATUS QUO**	**PROPOSED**
A. Current number of cartridges (online and offline)		16,000	
B. Native cartridge capacity		20 GB	40 GB
C. Average cartridge utilization		50%	50%
D. Average utilized cartridge capacity		10 GB	20 GB
E. Initial number of cartridges (online and offline)		16,000	8,000
F. Data stored on tape		160 TB	160 TB
G. Cartridges purchased for initial conversion			8,000
H. Data growth		50%	50%
I. Recycling of worn cartridges		10%	10%
J. Additional cartridge purchases in Year 1		9,600	4,800
K. Discounted price per cartridge		$70	$90
L. Assumed annual cartridge price decline		10%	10%
D = B * C			
E (PROPOSED) = A (STATUS QUO) * D (STATUS QUO) / D (PROPOSED)			
F = D * E (THE STATUS QUO AND PROPOSED SOLUTIONS STORE THE SAME AMOUNT OF DATA)			
G (PROPOSED) = E (PROPOSED)			
J = E * (H + I)			
CASH FLOW	**INVESTMENT**	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cartridges purchased		9,600	15,360	24,576

Status quo price per cartridge	$70	$67	$60	$54
Status quo cost		$640,000	$920,000	$1,320,000
Proposed cartridges purchased	8,000	4,800	7,680	12,288
Proposed price per cartridge	$90	$86	$77	$69
Proposed cost	$720,000	$410,000	$590,000	$850,000
Excess cost of status quo	-$720,000	$230,000	$330,000	$470,000
CARTRIDGES PURCHASED IN YEAR 1 = J				
CARTRIDGES PURCHASED IN YEARS 2–3 = CARTRIDGES PURCHASED IN PRIOR YEAR * (1 + H + I)				
PRICE PER CARTRIDGE IN YEAR 1 = K * (1–L / 2)				
PRICE PER CARTRIDGE IN YEARS 2–3 = PRICE PER CARTRIDGE IN PRIOR YEAR * (1–L)				

The example above assumed a worst-case purchase of enough proposed cartridges to convert all data from current cartridges, before the new library is installed. In fact, current cartridges can sometimes be reformatted as the new media. In other cases, the customer might decide against an initial conversion, and write on the proposed cartridges only when new data is created during normal processing.

The following example illustrates the case where media is reusable in the next generation of the tape drive, leading to reduced proposed purchases in the near term. In this example, every two current status quo cartridges are converted into one proposed cartridge before the proposed library goes into operation, leaving half the status quo cartridges available to fulfill future growth requirements.

TABLE 4. MEDIA REPLACEMENT WITH REUSE OF MEDIA IN NEW TAPE DRIVES

CASH FLOW	INVESTMENT	YEAR 1	YEAR 2	YEAR 3
Status quo cartridges purchased		9,600	15,360	24,576
Status quo price per cartridge	$70	$67	$60	$54
Status quo cost		$640,000	$920,000	$1,320,000
Proposed cartridge demand		4,800	7,680	12,288
Proposed cartridge excess inventory (at year end)	8,000*	3,200	0	0
Proposed cartridges purchased	0	0	4,480	12,288
Proposed price per cartridge	$90	$86	$77	$69
Proposed cost	$0	$0	$345,000	$850,000
Excess cost of status quo	$0	$640,000	$575,000	$470,000

*After the 16,000 status quo cartridges were converted into 8,000 proposed cartridges, 8,000 cartridges remained as excess inventory available to satisfy future growth.

Offline Cartridge Storage

Tape cartridges, and the data they hold, are often removed from the library and stored either locally in the datacenter (offline), or offsite (vaulted) as in this illustrative business case. There are two kinds of costs associated with both offline and vaulted storage—the cost of moving the cartridges to and from the storage facility and the cost of actually storing them.

In this example, the greater capacity of the proposed cartridges leads to a smaller number that need to be moved and stored offline. Using a library as a disaster recovery site, which is not the situation in the illustrative business case, could also reduce offline cartridge storage costs.

TABLE 5. STATUS QUO AND PROPOSED OFFLINE CARTRIDGE STORAGE ASSUMPTIONS AND COSTS

OFFLINE CARTRIDGE STORAGE ASSUMPTIONS	STATUS QUO	PROPOSED
A. Number of cartridges (online and offline)	16,000	8,000
B. Total number of cartridges stored online	11,000	6,000
C. Number of cartridges stored offline	5,000	2,000
D. Monthly cost per cartridge stored offline	$0.50	$0.50
E. Annual cost of storing cartridges	$30,000	$12,000
F. Monthly number of cartridges moved offline and back	10,000	4,000
G. Cost per moved cartridge	$0.50	$0.50
H. Annual cost of moving cartridges	$60,000	$24,000
I. Data growth	50%	50%
C = A–B		
E = C * D * 12 MONTHS PER YEAR		
H = F * G * 12 MONTHS PER YEAR		

CASH FLOW	YEAR 1	YEAR 2	YEAR 3
Status quo cost	$90,000	$135,000	$203,000
Proposed cost	$36,000	$54,000	$81,000
Excess cost of status quo	$54,000	$81,000	$122,000
YEAR 1 = E + H			
YEAR 2–3 = PRIOR YEAR * (1 + I)			

Hardware Maintenance

This value driver compares the status quo and proposed hardware maintenance costs, over the financial horizon. In this illustrative business case, the proposed hardware maintenance cost is less than status quo, because fewer libraries and drives are required.

Most storage hardware vendors offer premium 24/7 maintenance as well as next day maintenance, the latter costing perhaps half the former.

Most storage hardware vendors also provide an initial warranty period, usually 12 months, during which maintenance is provided at either no cost or reduced cost. Maintenance 24/7, as in the illustrative business case, is provided during the warranty period at a warranty uplift cost equal to the differential between 24/7 and next day maintenance cost. In case the enterprise had opted for next-day maintenance, there would have been $0 of cost in year 1 of the proposed solution, instead of $35,000.

TABLE 6. STATUS QUO AND PROPOSED HARDWARE MAINTENANCE ASSUMPTIONS AND COSTS

HARDWARE MAINTENANCE ASSUMPTIONS			STATUS QUO	PROPOSED
A. Monthly 24/7 maintenance price, after discount, for all libraries, after the warranty period			$5,000	$2,000
B. Library warranty period				12 months
C. Monthly 24/7 maintenance price, after discount, for all libraries, during the warranty period				$900
D. Number of drives			45	25
E. Monthly 24/7 maintenance price, after discount, per drive, after the warranty period			$160	$180
F. Drive warranty period				12 months
G. Monthly 24/7 maintenance price, after discount, per drive, during the warranty period				$80
CASH FLOW		**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost		$137,000	$137,000	$137,000
Proposed cost		$35,000	$78,000	$78,000
Excess cost of status quo		$102,000	$59,000	$59,000
STATUS QUO = 12 MONTHS * (A + (D * E))				
PROPOSED YEAR 1 = 12 MONTHS * (C + (D * G))				
PROPOSED YEAR 2–3 = 12 MONTHS * (A + (D * E))				

In this example, the maintenance costs are not escalated in anticipation of future years.

Software Acquisition and Maintenance

This value driver reflects the upfront software acquisition cost for the proposed library and annual software maintenance costs for both status quo and proposed libraries. In the illustrative business case, the new proposed library requires acquisition of a software suite to optimize its operation.

TABLE 7. STATUS QUO AND PROPOSED SOFTWARE ASSUMPTIONS AND COSTS

SOFTWARE ASSUMPTIONS			STATUS QUO	PROPOSED
A. Library software acquisition cost				$20,000
B. Monthly software maintenance cost for all libraries			$2,500	$1,500
CASH FLOW	**INVESTMENT**	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost		$30,000	$30,000	$30,000
Proposed cost	$20,000	$18,000	$18,000	$18,000
Excess cost of status quo	-$20,000	$12,000	$12,000	$12,000
YEAR 1–3 = 12 MONTHS * B				

Environmental

Certain enterprises are exceedingly concerned with the cost of datacenter space. For others, this is an inconsequential issue. In this example, the single proposed library occupies significantly less datacenter space than the three status quo libraries. Power and cooling may also be key issues. Again, the single

proposed library uses less electricity than the three status quo libraries. Power consumed by tape drives is considered too insignificant for inclusion in this example.

TABLE 8. STATUS QUO AND PROPOSED ENVIRONMENTAL ASSUMPTIONS AND COSTS

ENVIRONMENTAL ASSUMPTIONS	STATUS QUO	PROPOSED
A. Square feet of raised floor space for all libraries, including service clearance room	900	150
B. Cost per square foot per month	$20	$20
C. Annual cost of floor space	$216,000	$36,000
D. Monthly power requirement for all libraries, in kilowatt hours (kWh)	4,000	2,000
E. Power cost per kWh	$0.25	$0.25
F. Annual power cost	$12,000	$6,000
G. Cooling as percent of power cost	50%	50%
H. Annual cooling cost	$6,000	$3,000
C = A * B * 12 MONTHS		
F = D * E * 12 MONTHS		
H = F * G		

CASH FLOW	YEAR 1	YEAR 2	YEAR 3
Status quo cost	$234,000	$234,000	$234,000
Proposed cost	$45,000	$45,000	$45,000
Excess cost of status quo	$189,000	$189,000	$189,000
YEAR 1–3 = C + F + H			

Wide-Area Network

In the illustrative business case, status quo and proposed libraries are connected to servers via a local-area network (LAN), and therefore they incur no wide-area network (WAN) communication costs. If the proposed solution had introduced a new disaster recovery library, then this WAN cost would have been included.

Virtual tape solutions can reduce WAN costs by reducing actual traffic to and from a remote library, and by reducing maximum bandwidth by smoothing otherwise "bursty" communication.

WAN costs have two major components. The first includes the costs of telecommunications hardware on the enterprise premises. The second includes the costs incurred with telecommunications carriers, such as those for a T1 connection.

Other Implementation Costs

This value driver serves as a catchall for miscellaneous up-front implementation costs of the proposed storage solution, which are often overlooked or ignored. The activity of preparation and due diligence measures the time and cost needed by the enterprise's storage architects to evaluate the proposed solution, visit user sites, prepare management presentations, and plan for implementation.

Installation disruption measures the cost of not being able to run applications while replacing the libraries. To eliminate installation disruption and reduce implementation risk, many enterprises perform parallel operation, where the current and proposed libraries operate simultaneously for some period. The cost of parallel operation is not shown in this example.

TABLE 9. STATUS QUO AND PROPOSED MISCELLANEOUS ASSUMPTIONS AND COSTS

OTHER IMPLEMENTATION COST ASSUMPTIONS			STATUS QUO	PROPOSED
A. Work months for preparation and due diligence				2.0
B. Preparation and due diligence cost per month				$10,000
C. Number of administrators trained				12
D. Training classes per administrator				2.0
E. Cost per training class				$500
F. Current cartridges converted to proposed				16,000
G. Conversion cost per cartridge				$4.00
H. Freight for delivering proposed library				$3,000
I. Deinstallation of current libraries				$2,000
J. Installation of proposed library				$11,000
K. Hours of installation disruption				20
L. Cost per hour of scheduled downtime				$1,000
CASH FLOW	**INVESTMENT**	**YEAR 1**	**YEAR 2**	**YEAR 3**
Preparation and due diligence	$20,000			
Training	$12,000			
Cartridge conversion	$64,000			
Library installation	$16,000			
Installation disruption	$20,000			
Proposed cost	$132,000			
Excess cost of status quo	-$132,000			
PREPARATION AND DUE DILIGENCE = A * B				
TRAINING = C * D * E				
CARTRIDGE CONVERSION = F * G				
LIBRARY INSTALLATION = H + I + J				
INSTALLATION DISRUPTION = K * L				

Storage Architect Productivity

A storage architect sets policies, evaluates solutions and vendors, and designs storage solutions.

This value driver quantifies the difference in storage architect staffing costs between the status quo and proposed solutions. Certain storage solutions have superior library interoperability, library consolidation capability, drive support/certification, ability of virtual tape to isolate applications from technology changes, and other features that improve storage architect productivity.

In the illustrative business case, assume that the enterprise currently has 2.5 full-time equivalent (FTE) staff members performing tape storage architect activities. This could be two people working full-time plus one person half-time, or five individuals each devoting half their time to architect activities. The proposed solution requires only 2.0 storage architects, for a productivity savings of 0.5 FTEs. Because of its library consolidation capability, the proposed solution was more effective, 90 percent versus 50 percent, at enabling storage architect productivity.

TABLE 10. STATUS QUO AND PROPOSED STORAGE ARCHITECT PRODUCTIVITY ASSUMPTIONS AND COSTS

STORAGE ARCHITECT PRODUCTIVITY ASSUMPTIONS		STATUS QUO	PROPOSED
A. Full-time equivalent storage architects (FTEs)		2.5	
B. Potential productivity improvement with perfect solution			50%
C. Solution effectiveness at enabling storage architect productivity		50%	90%
D. "To be" full-time equivalent storage architects (FTEs)		2.5	2.0
E. Annual storage architect fully burdened salary		$120,000	$120,000
D (PROPOSED) = A * (1–B * (C (PROPOSED)–C (STATUS QUO))			
CASH FLOW	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost	$300,000	$300,000	$300,000
Proposed cost	$240,000	$240,000	$240,000
Excess cost of status quo	$60,000	$60,000	$60,000
COST = D * E			

The storage management staffing examples conservatively show the same benefit in Years 2 and 3 as in Year 1. In fact, the benefit could increase as the data grows and/or salaries increase. This effect might be offset by the enterprise's expectation that better hardware and software tools will allow the same staff to manage more data, regardless of the solution.

Storage Administrator Productivity

Activities of a storage administrator include the following:

- Install hardware
- Test system
- Write backup/recovery scripts
- Update/maintain software/scripts/agents
- Install software and/or agents
- Order hardware
- Plan capacity: hardware, software, media
- Order software
- Update/maintain hardware

This value driver quantifies the difference in storage administrator staffing costs between the status quo and proposed solutions. Certain libraries have superior reliability, ease of adding capacity, ability to service on the fly, and other features that improve administrator productivity.

In the illustrative business case, assume that the enterprise currently has 10.0 FTE staff members performing tape storage administrator activities. The proposed solution requires only 9.0 storage administrators, for a productivity savings of 1.0 FTEs. The proposed solution was more effective in enabling storage administrator productivity, 90 percent versus 70 percent, because of its superior reliability, ease of adding capacity, and ability to service on the fly.

The proposed solution was penalized for two months of ramp-up time, during which the 9.0 storage administrators were only 50 percent productive while mastering the new storage technology.

TABLE 11. STATUS QUO AND PROPOSED STORAGE ADMINISTRATOR ASSUMPTIONS AND COSTS

STORAGE ADMINISTRATOR PRODUCTIVITY ASSUMPTIONS		STATUS QUO	PROPOSED
A. Full-time equivalent storage administrators (FTEs)		10.0	
B. Potential productivity improvement with perfect solution			50%
C. Solution effectiveness at enabling storage administrator productivity		70%	90%
D. "To be" full-time equivalent storage administrators (FTEs)		10.0	9.0
E. Work months per FTE for productivity ramp-up			2.0
F. Annual storage administrator fully burdened salary		$80,000	$80,000
G. Productivity ramp-up cost			$60,000
D (PROPOSED) = A * (1–B * (C (PROPOSED)–C (STATUS QUO))			
G = D * E * F / 12 MONTHS * 50% PRODUCTIVITY LOSS			
CASH FLOW	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost	$800,000	$800,000	$800,000
Proposed cost	$780,000	$720,000	$720,000
Excess cost of status quo	$20,000	$80,000	$80,000
YEAR 1 = (D * F) + G			
YEAR 2–3 = D * F			

Operator Productivity

Operators run backup and recovery tasks.

In the illustrative business case, assume that the enterprise currently has 3.0 operators. The proposed solution requires only 1.0 operator, for a productivity savings of 2.0 FTEs. The proposed solution reduced the need for operators by consolidating three libraries into one.

The proposed solution was slightly penalized for three months of operator ramp-up time, during which the operator was only 50 percent productive while mastering the new storage technology.

TABLE 12. STATUS QUO AND PROPOSED OPERATOR PRODUCTIVITY ASSUMPTIONS AND COSTS

OPERATOR PRODUCTIVITY ASSUMPTIONS		STATUS QUO	PROPOSED
A. Full-time equivalent operators (FTEs)		3.0	
B. Number of libraries		3	1
C. "To be" full-time equivalent operators (FTEs)		3.0	1.0
D. Work months per FTE for productivity ramp-up			3.0
E. Annual operator fully burdened salary		$40,000	$40,000
F. Productivity ramp-up cost			$5,000
C (PROPOSED) = A * B (PROPOSED) / B (STATUS QUO)			
F = C * D * E / 12 MONTHS * 50% PRODUCTIVITY LOSS			
CASH FLOW	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost	$120,000	$120,000	$120,000
Proposed cost	$45,000	$40,000	$40,000
Excess cost of status quo	$75,000	$80,000	$80,000
YEAR 1 = (C * E) + F			
YEAR 2–3 = C * E			

Unscheduled Downtime

In this illustrative business case, the tape libraries are scheduled to operate 24 hours per day, 365 days per year, which equals 8,760 annual hours. A major benefit of the proposed library is its enhanced reliability, mostly due to redundant robots and power supply. Improved reliability leads to less unscheduled downtime. Each enterprise has a unique cost of unscheduled application downtime, often related to lost revenue, impaired customer reputation, and costly workarounds.

When the library fails, the entire tape storage system is unavailable, affecting all its users and applications. When an individual tape drive fails, there is a lesser cost of unscheduled downtime for a single user. This example does not claim a reliability improvement for the proposed drives. However, there are more status quo drives that might fail, leading to more hours of unscheduled drive downtime and higher cost of ownership.

TABLE 13. STATUS QUO AND PROPOSED UNSCHEDULED DOWNTIME ASSUMPTIONS AND COSTS

UNSCHEDULED DOWNTIME ASSUMPTIONS	STATUS QUO	PROPOSED
A. Annual hours of operation	8,760	8,760
B. Library reliability	99%	99.99%
C. Unscheduled system downtime hours per year	88	1
D. Cost per hour of unscheduled system downtime	$10,000	$10,000
E. Tape drive reliability	99.90%	99.90%
F. Number of tape drives	40	25
G. Unscheduled tape drive downtime hours per year	350	219
H. Cost per hour of unscheduled drive downtime	$100	$100

C = A * (1–B)			
G = A * (1–E) * F			
CASH FLOW	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost	$915,000	$915,000	$915,000
Proposed cost	$32,000	$32,000	$32,000
Excess cost of status quo	$883,000	$883,000	$883,000
COST = (C * D) + (G * H)			

The application performance examples conservatively show the same benefit in Years 2 and 3 as in Year 1. In fact, the benefit could increase as the enterprise's revenue and cost of downtime grow.

Scheduled Downtime

This value driver quantifies the reduced cost of scheduled downtime from the status quo to the proposed solution, recognizing that some libraries require time-consuming scheduled downtime to perform routine maintenance. The proposed library has less scheduled downtime because it is designed to be serviced while operating and allows capacity increases with little or no interruption to operation.

Each enterprise has a unique cost of scheduled tape storage downtime that is generally less than the cost of unscheduled downtime. The cost of scheduled downtime would be greatest for a 24/7 operating environment.

TABLE 14. STATUS QUO AND PROPOSED SCHEDULED DOWNTIME ASSUMPTIONS AND COSTS

SCHEDULED DOWNTIME ASSUMPTIONS	STATUS QUO	PROPOSED
A. Annual scheduled downtime hours	100	10
B. Cost per hour of scheduled system downtime	$2,000	$2,000
CASH FLOW	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost	$200,000	$200,000	$200,000
Proposed cost	$20,000	$20,000	$20,000
Excess cost of status quo	$180,000	$180,000	$180,000
COST = A * B			

Data Recovery Speed

This value driver quantifies the reduced cost of elapsed data recovery time from the status quo to the proposed solution. Because the proposed solution uses tape drives with twice the throughput speed, data can be restored more quickly when recovery is needed, reducing the amount and cost of unscheduled application downtime.

TABLE 15. STATUS QUO AND PROPOSED DATA RECOVERY SPEED ASSUMPTIONS AND COSTS

DATA RECOVERY SPEED ASSUMPTIONS	STATUS QUO	PROPOSED
A. Annual number of recovery incidences	20	20
B. Average recovery time in hours	2	1
C. Annual unscheduled downtime during application recovery in hours	40	20

D. Cost per hour of unscheduled downtime		$10,000	$10,000
C = A * B			
CASH FLOW	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost	$400,000	$400,000	$400,000
Proposed cost	$200,000	$200,000	$200,000
Excess cost of status quo	$200,000	$200,000	$200,000
COST = C * D			

Backup Window Duration

In this illustrative business case, the faster proposed tape drives allow for faster data backup. This benefit of proposed over status quo can be realized in several ways:

- The enterprise reduces its current backup window, thereby reducing unscheduled downtime and gaining the benefit of more revenue or other application value. This is the quantification method actually used in the example.
- The enterprise incurs less risk of failing to complete backups within the prescribed window, incurring less cost of lost data when restoration is necessary.
- The enterprise takes advantage of room within the backup window to add new applications.

TABLE 16. STATUS QUO AND PROPOSED BACKUP WINDOW DURATION ASSUMPTIONS AND COSTS

BACKUP WINDOW DURATION ASSUMPTIONS	**STATUS QUO**	**PROPOSED**
A. Backup window, hours per day	4	3
B. Backup frequency, days per year	365	365
C. Application unavailability, hours per year	1,460	1,095
D. Application unavailability, hours per year	$2,000	$2,000
C = A * B		
CASH FLOW	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost	$2,920,000	$2,920,000	$2,920,000
Proposed cost	$2,190,000	$2,190,000	$2,190,000
Excess cost of status quo	$730,000	$730,000	$730,000
COST = C * D			

Batch Tape Processing Time

Some enterprises have mainframe legacy applications that use tape as an intermediate and final storage medium, rather than as a backup medium for disk.

The faster tape drives introduced by this proposed solution will help the enterprise complete its tape processing applications in less time. The calculation is based on an assumed cost per hour charged by the datacenter performing the tape processing.

Other interpretations of this value driver are

- The enterprise is currently pressuring its 24-hour or shorter processing schedule, and faster tape processing will allow deferral of costly hardware upgrades.
- The enterprise can add new valuable applications to its processing schedule.

TABLE 17. STATUS QUO AND PROPOSED BATCH TAPE PROCESSING TIME ASSUMPTIONS AND COSTS

BATCH TAPE PROCESSING TIME ASSUMPTIONS		STATUS QUO	PROPOSED
A. Tape processing time, hours per day		8	6
B. Tape processing time, days per year		365	365
C. Tape processing time, hours per year		2,920	2,190
D. Cost per hour of tape processing		$200	$200
C = A * B			
CASH FLOW	**YEAR 1**	**YEAR 2**	**YEAR 3**
Status quo cost	$584,000	$584,000	$584,000
Proposed cost	$438,000	$438,000	$438,000
Excess cost of status quo	$146,000	$146,000	$146,000
COST = C * D			

Transaction Response Time

Some enterprises use tape storage as a fast access archive. The users, for example, might be at a call center retrieving customer data and providing customer service. Because the proposed solution has a faster average access time, information retrieval is faster, and users have less waiting time for the application to respond.

In this example, the benefit of faster response time is quantified in terms of less lost user productivity. It assumes that each user loses 25 percent productivity while waiting for response, and can still be 75 percent productive doing something else while waiting. In fact, slow response could result in poor customer service, incurring an even greater cost.

TABLE 18. STATUS QUO AND PROPOSED TRANSACTION RESPONSE TIME ASSUMPTIONS AND COSTS

TRANSACTION RESPONSE TIME ASSUMPTIONS		STATUS QUO	PROPOSED
A. Average tape application usage, hours per day per user		8	8
B. Information requests per hour per user		10	10
C. Average response time per request, seconds		60	20
D. User hours per day awaiting response		1.33	.44
E. Annual fully burdened user salary plus benefits		$40,000	$40,000
F. Productivity loss awaiting response		25%	25%
G. Annual tape responsiveness cost per user		$1,667	$556
H. Number of tape application users		100	100
D = A * B * C / 3,600 seconds per hour			
G = D / 8 work hours per day * E * F			
Cash Flow	**YEAR 1**	**YEAR 2**	**YEAR 3**

Status quo cost	$167,000	$167,000	$167,000
Proposed cost	$56,000	$56,000	$56,000
Excess cost of status quo	$111,000	$111,000	$111,000
COST = G * H			

Backup Reliability

This value driver quantifies the reduced cost of unreliable backups from the status quo to the proposed solution. In the event that recovery is needed, unsuccessful backups lead to costly irrecoverable data loss. Storage solutions with greater reliability and cartridges with greater durability improve the likelihood that backups will be successful.

This illustrative business case assumes that the proposed library is more reliable, increasing successful backups from 70 percent to 90 percent.

TABLE 19. STATUS QUO AND PROPOSED BACKUP RELIABILIITY ASSUMPTIONS AND COSTS

BACKUP RELIABILITY ASSUMPTIONS	STATUS QUO	PROPOSED
A. Successful backups	70%	90%
B. Annual restorations	20	20
C. Annual unsuccessful restorations	6	2
D. Average application processing hours since previous successful backup	8	8
E. Cost per hour of irrecoverable data	$10,000	$10,000
C = (1–A) * B		

Cash Flow	YEAR 1	YEAR 2	YEAR 3
Status quo cost	$480,000	$480,000	$480,000
Proposed cost	$160,000	$160,000	$160,000
Excess cost of status quo	$320,000	$320,000	$320,000
COST = C * D * E			

The business risk mitigation examples conservatively show the same benefit in Years 2 and 3 as in Year 1. In fact, the benefit could increase as the enterprise's revenue, cost of irrecoverable data, and cost of disaster downtime grows.

Disaster Recovery

This value driver quantifies the reduced cost of recovering from potential disasters. Storage solutions with greater reliability and throughput can recover information more quickly following a disaster, thereby getting the enterprise back into operation sooner. The cost of disaster downtime is usually greater than unscheduled downtime because all business applications are affected, and for a greater length of time.

This illustrative business case assumes that the proposed library is more reliable and the tape drives faster than the status quo solution.

TABLE 20. STATUS QUO AND PROPOSED DISASTER RECOVERY ASSUMPTIONS AND COSTS

DISASTER RECOVERY ASSUMPTIONS	STATUS QUO	PROPOSED
A. Hours to recover from a disaster	25	10
B. Cost per hour of disaster downtime	$100,000	$100,000
C. Cost of a disaster	$2,500,000	$1,000,000
D. Probability of a disaster within one year	3%	3%
C = A * B		

Cash Flow	YEAR 1	YEAR 2	YEAR 3
Status quo cost	$75,000	$75,000	$75,000
Proposed cost	$30,000	$30,000	$30,000
Excess cost of status quo	$45,000	$45,000	$45,000
COST = C * D			

Financial Measurement

After reviewing all the potential value drivers, a decision must be made as to which ones to include in the final business case. Then the excess cost of status quo from each selected value driver are aggregated to calculate the total cash flows for the upfront investment and for each year of the financial horizon.

TABLE 21. EXCESS COST OF STATUS QUO VALUE DRIVERS

EXCESS COST OF STATUS QUO	INVESTMENT	YEAR 1	YEAR 2	YEAR 3
Hardware	-$700,000	$0	$0	$0
Media	-$720,000	$230,000	$330,000	$470,000
Offline cartridge storage		$54,000	$81,000	$122,000
Hardware maintenance		$102,000	$59,000	$59,000
Software	-$20,000	$12,000	$12,000	$12,000
Environment		$189,000	$189,000	$189,000
Other implementation costs	-$132,000			
Operator productivity		$75,000	$80,000	$80,000
Unscheduled downtime		$883,000	$883,000	$883,000
Backup reliability		$320,000	$320,000	$320,000
Total	-$1,572,000	$1,865,000	$1,954,000	$2,135,000

It is now time for financial measurement, based on the total line above.

Investment

The investment in the proposed tape storage solution is $1,572,000.

Cost of Capital

Each enterprise has a unique cost of capital (see the Appendix) or discount rate used to calculate the present value of future cash flows. For this illustrative business case, let us assume that the enterprise's cost of capital is 8 percent.

Discounted Total Cost of Ownership Savings

Discounted TCO savings is the primary financial measure applied to this financial decision. The calculation of this measure is based upon the net present value (NPV) of future cash flows. While the investment of $1,572,000 is cash today, Years 1 through 3 are future cash flows. These future cash flows can be converted to their present value using the 8 percent cost of capital. As shown in this table, $1,694,832 invested with 8 percent compounded interest rate would grow to $2,135,000 in Year 3.

TABLE 22. NET PRESENT VALUE OF FUTURE CASH FLOWS

	FUTURE VALUE	PRESENT VALUE (8% COST OF CAPITAL)
Investment		-$1,572,000
Year 1	$1,865,000	$1,726,852
Year 2	$1,954,000	$1,675,240
Year 3	$2,135,00	$1,694,832
Net present value		$3,524,924

The discounted TCO savings offered by the proposed solution is $3,524,924.

For Excel users, this formula: =–1572000+NPV(8%,1865000,1954000,2135000) would calculate this same answer.

The next step is the calculation of some additional financial measures that may be of interest to some enterprises.

Net Present Value of Benefits

The net present value in the table above was calculated as the total of the investment plus the present value of each future year. Net present value of benefits is simply the total present value of the future years, ignoring the investment.

The net present value of benefits offered by the proposed solution is $5,096,924.

Return on Investment

The return on investment (ROI) is the net present value of benefits, $5,096,924, divided by the investment ($1,572,000).

The ROI offered by the proposed solution is 324 percent.

Internal Rate of Return

The internal rate of return (IRR; see Appendix for definition) equals the cost of capital at which the net present value would be zero.

The IRR offered by the proposed solution is 109 percent.

For Excel users, this formula: =IRR(Range,.1) calculates to 109 percent when range is:

–$1,572,000	$1,865,000	$1,954,000	$2,135,000

Within the formula, .1 represents an initial guess at the result.

This formula: =–1572000+NPV(109%,1865000,1954000,2135000) would calculate to $0.

Cumulative Cash Flow

Cumulative cash flow measures the difference in cash position between the proposed and status quo solutions.

TABLE 23. CUMULATIVE CASH FLOW

	CUMULATIVE CASH FLOW AT BEGINNING OF YEAR	CASH FLOW DURING THE YEAR
Year 1	–$1,572,000	$1,865,000
Year 2	$293,000	$1,954,000
Year 3	$2,247,000	$2,135,000
Year 4	$4,382,000	

At the beginning of Year 1, the proposed solution is in the red for $1,572,000 because of the initial investment in hardware, media, software, and other implementation costs. By the end of Year 1, which is the beginning of Year 2, the proposed solution has climbed out of the red into positive territory. At this point, cumulative cash flow is $293,000.

Payback

Payback is simply the number of months, from the beginning of Year 1, that it takes for the cumulative cash flow to climb back to $0. Since Year 1 began at –$1,572,000 and ended at $293,000, the assumption is that $0 was crossed approximately 10 months into Year 1.

The payback offered by the proposed solution is 10 months.

For Excel users, this formula: =12–293000/1865000*12 calculates this result.

Cost of Delay

Deferring the savings offered by a project results in a penalty related to both the magnitude of those savings and the enterprise's cost of capital. If the enterprise were to delay the project for a full year, the cost of delay, $282,000, would equal cost of capital (8%) * discounted TCO savings, $3,524,924.

If, unlike in the illustrative business case, the enterprise were leasing current equipment, the cost of delay would be offset by the reduced lease termination penalties introduced by the delay.

The cost of a three-month delay of the proposed solution is approximately $70,000 (3/12 * $282,000).

Conclusion

The framework and financial methodology presented in this white paper are useful in determining whether an enterprise should replace its current status quo tape storage solution with a new proposed solution. The focus and emphasis is on the process and financial analysis. Although Oracle presents this white paper for informational purposes only and it is not an Oracle proposal or guarantee of results, the financial framework and methodology used to create the illustrative business case can easily be applied to any organization to realize the cost savings available with the new proposed tape storage solution.

Acknowledgement

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Appendix 1: Glossary

The following glossary is in two sections: Financial Terms and Storage Terms.

Financial Terms

The following terms apply in general to financial evaluation of projects:

- **Cash flow.** Cash flow is money that an enterprise must spend, either up front or in future years, to provide a storage solution. For example, money spent to acquire a new storage device is a cash outflow. Revenue improvement, due to less application downtime, is a cash inflow.
- **Cost of capital.** Cost of capital is the minimum required rate of return, or discount rate, that a new project investment must offer to be attractive. It is the required return that the firm must earn on its capital investment in a project just to break even. It is the opportunity cost associated with the enterprise's capital investment, defined as the most valuable alternative if the investment is not undertaken. When evaluating a potential investment, enterprises use their unique cost of capital to discount future cash flows.

  In academic terms, cost of capital is typically derived from an enterprise's weighted average cost of capital, or WACC. WACC measures weighted average after tax costs of debt financing and required market return on equity. Some enterprises will use WACC as their standard cost of capital value, but it is not uncommon to use a higher or lower rate to adjust for an increase or decrease in project-specific risk. A typical cost of capital in today's low interest rate environment might be 7 to 10 percent.
- **Cost of three-month delay.** The cost of three-month delay is the cost of deferring realization of the net present value, less any reduced lease termination fees, in the event of project delay. The cost of deferring the net present value for a full year would equal the cost of capital * the net present value of the proposed solution, and a three-month deferral would cost ¼ of this figure.
- **Discounted cash flow.** Discounted cash flows apply the cost of capital to future cash flows, and convert them to present value using the concept "time value of money." Time value of money refers to the fact that a dollar in hand today is worth more than a dollar promised at some time in the future. On a practical level, one reason for this is that you could earn interest while you waited; so a dollar today would grow to more than a dollar later. The trade-off between money now and money later thus depends on, among other things, the rate you can earn by investing and the overall rate of inflation.
- **Financial planning horizon.** The financial planning horizon is the number of years over which the enterprise chooses to evaluate the investment in a new storage solution. An enterprise's financial planning horizon can be as short as one year or extend to as many as seven or more years.
- **Full-time equivalents (FTEs).** FTEs equal the fractional number of full-time employees (working 40 hours per week) that would be required to perform a certain function. If two storage management

staff members each spend 60 percent of their time performing storage architect activities, the enterprise has 1.2 storage architect FTEs.

- **Fully burdened salary.** This is the annual salary plus employee-related overhead costs that include benefits, office space, travel expenses, and so on. A typical enterprise might have overhead costs of 35 percent.
- **Internal rate of return (IRR).** The IRR is the discount rate at which the net present value (NPV) would equal zero. For example, the NPV might be $5,000 with cost of capital set at 8 percent, but $0 with cost of capital set at 25 percent. In this case, IRR = 25 percent. Most enterprises will set a basic hurdle rate, greater than the cost of capital, and expect all projects to have an IRR exceeding that hurdle rate.
- **Investment.** Investments represent the upfront cash outflows (net of proceeds from deacquiring current hardware) that a company must make to undertake a project. Typical investments for storage solutions are hardware, media, and software purchase. Other costs considered as part of the overall investment amount include implementation costs such as installation, freight, installation disruption, parallel operation, preparation and due diligence, storage administrator training, and deinstallation fees. These costs are typically overlooked when defining an investment amount.
- **Net present value (NPV).** The net present value equals the investment (expressed as a negative cash flow) plus the net present value of benefits.
- **Net present value of benefits.** The net present value of benefits equals the present value of benefits over the financial horizon.
- **Nondiscounted cash flow.** A nondiscounted cash flow would simply be the arithmetic sum of the investment plus the future cash flow, without considering the cost of capital.
- **Payback.** The number of months, following installation of a solution, at which the cumulative cash flow climbs back to zero. After reaching this point, cumulative cash flow will be positive going forward. For example, if the proposed investment is $100,000, and the Year 1 status quo less proposed cash outflow is $100,000 as well, then the payback would be 12 months.
- **Present value (PV).** Calculate present value by discounting future cash flows over the financial planning horizon.
- **Return on investment (ROI).** Return on investment equals the net present value of benefits divided by the investment.
- **Total cost of ownership (TCO).** An enterprise's total cost of a storage solution typically includes costs such as hardware/software acquisition and maintenance, floor space and power, media purchases and storage, implementation of new technology, and storage management staffing. TCO also includes performance and risk mitigation issues such as unscheduled downtime, scheduled downtime, data recovery speed, backup window duration, batch tape processing time, transaction response time, backup reliability, and disaster recovery speed. TCO of future years is usually measured in terms of their present value.

Storage Terms

The following terms apply to tape storage solutions:

- **Average recovery time.** The average recovery time is the average time to recover from a recovery incident.
- **Backup window duration.** The amount of time during each 24-hour period, normally at night, required by an enterprise to suspend application operation in order to back up its data on tape.
- **Installation disruption.** Installation disruption is the cost of not being able to operate applications while installing a new storage solution.
- **Native capacity.** The native capacity is the maximum amount of data that a tape cartridge can hold.
- **Parallel operation.** Parallel operation is the excess cost of operating the current and new storage solutions at the same time.
- **Preparation and due diligence.** This is the cost of evaluating a new storage solution, evaluating vendors, visiting user sites, preparing management presentations, and architecting the implementation.
- **Productivity loss awaiting response.** This is the degree to which a tape user (perhaps at a credit card call center) loses productivity while waiting for data to be retrieved from tape and displayed on a video screen for further action.
- **Productivity ramp-up.** The productivity ramp-up is the period during which storage administrators or operators perform at less than 100 percent efficiency while becoming familiarized with a new storage solution.
- **Recovery incident.** Each recovery incident represents an occasion when an enterprise needs to restore data from backup storage. The cause of recovery incidences includes human error, software failure, hardware failure, or natural disaster.
- **Reliability.** Reliability is the percent of time that a library, drive, or virtual tape solution is expected to operate without unscheduled downtime.
- **Successful backups.** This is the percent of successfully completed backups so that the backed up data can be restored if necessary.
- **System availability.** This is the percent of time that the storage solution as a whole is expected to operate without unscheduled downtime.
- **Tape utilization.** Tape utilization is the average percent of a tape cartridge's native capacity that contains useful data. Some enterprises, particularly those utilizing a virtual tape solution, may have a tape utilization of 90 percent or even greater. Other enterprises, particularly those in a mainframe environment, may have a tape utilization of less than 50 percent.

- **Utilized capacity.** Average actual amount of data that a tape cartridge holds (= native capacity * tape utilization).
- **Vaulting.** Tape cartridges may be stored online in library slots, offline remotely, or offline on-premises. Vaulting refers to the two offline storage locations.

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Measuring the TCO of Tape Storage Solutions
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